

# **VIBRATION ISOLATION OF BENAROYA CONCERT HALL**

BY

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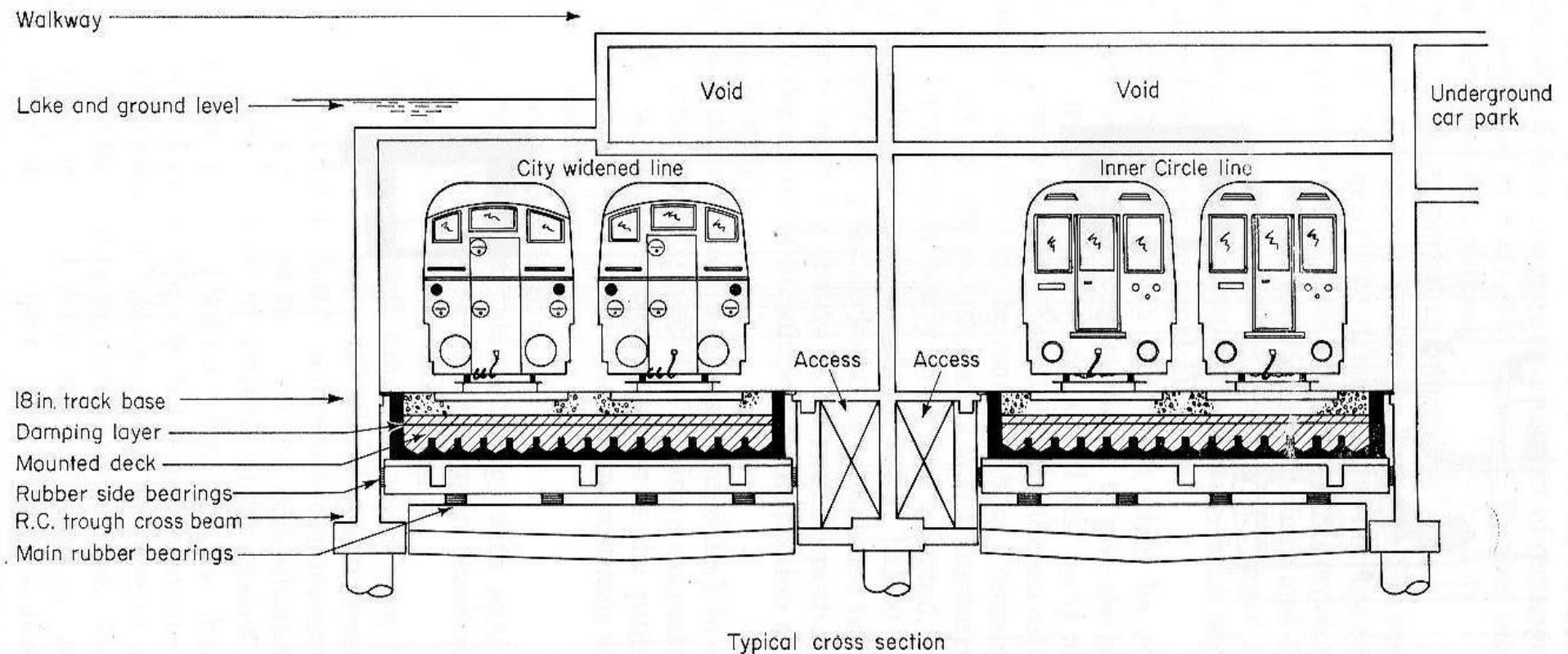
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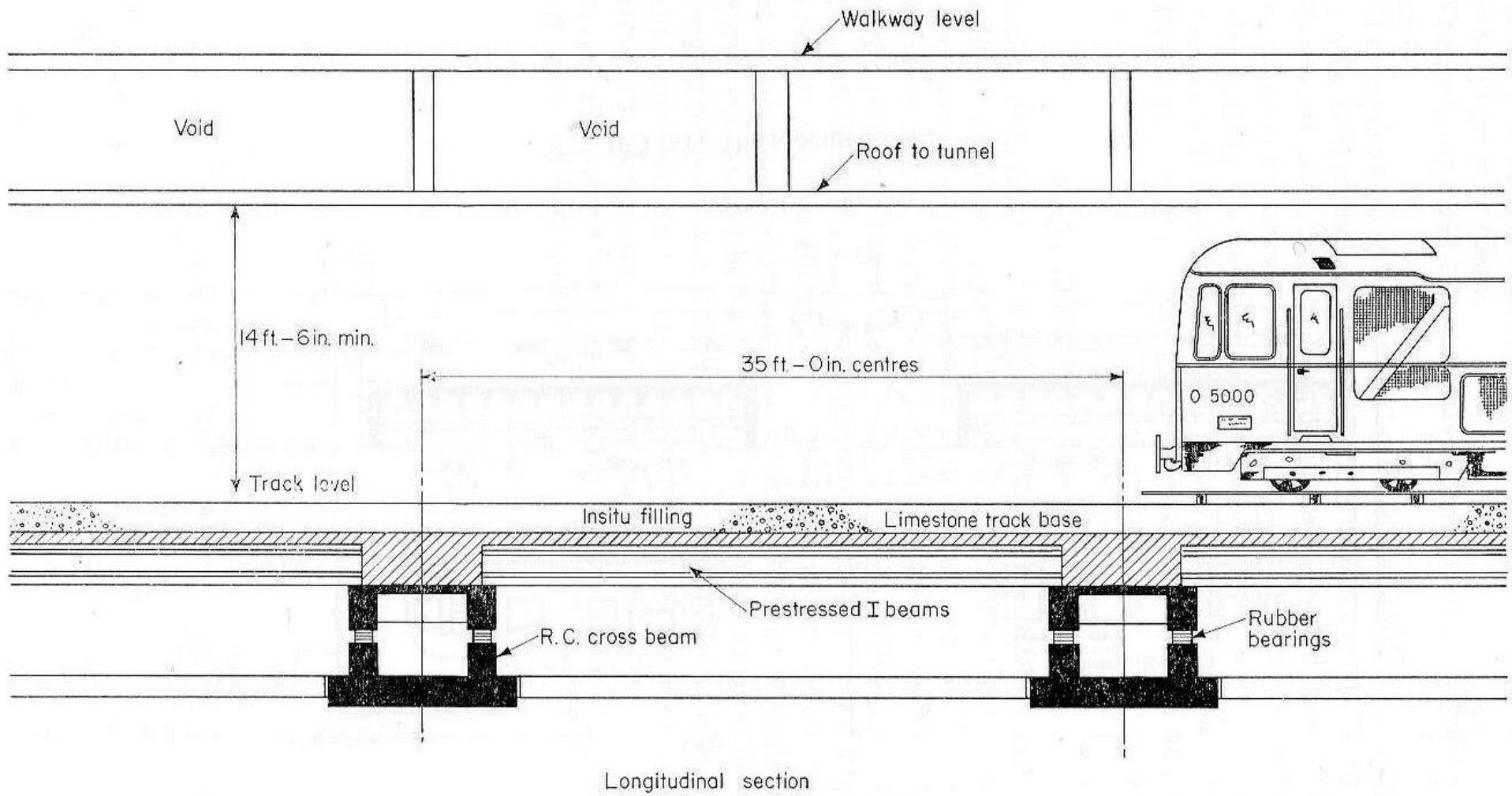
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## Barbican Scheme Floating Track - London - 1964





## Barbican Scheme Floating Track - London - 1964





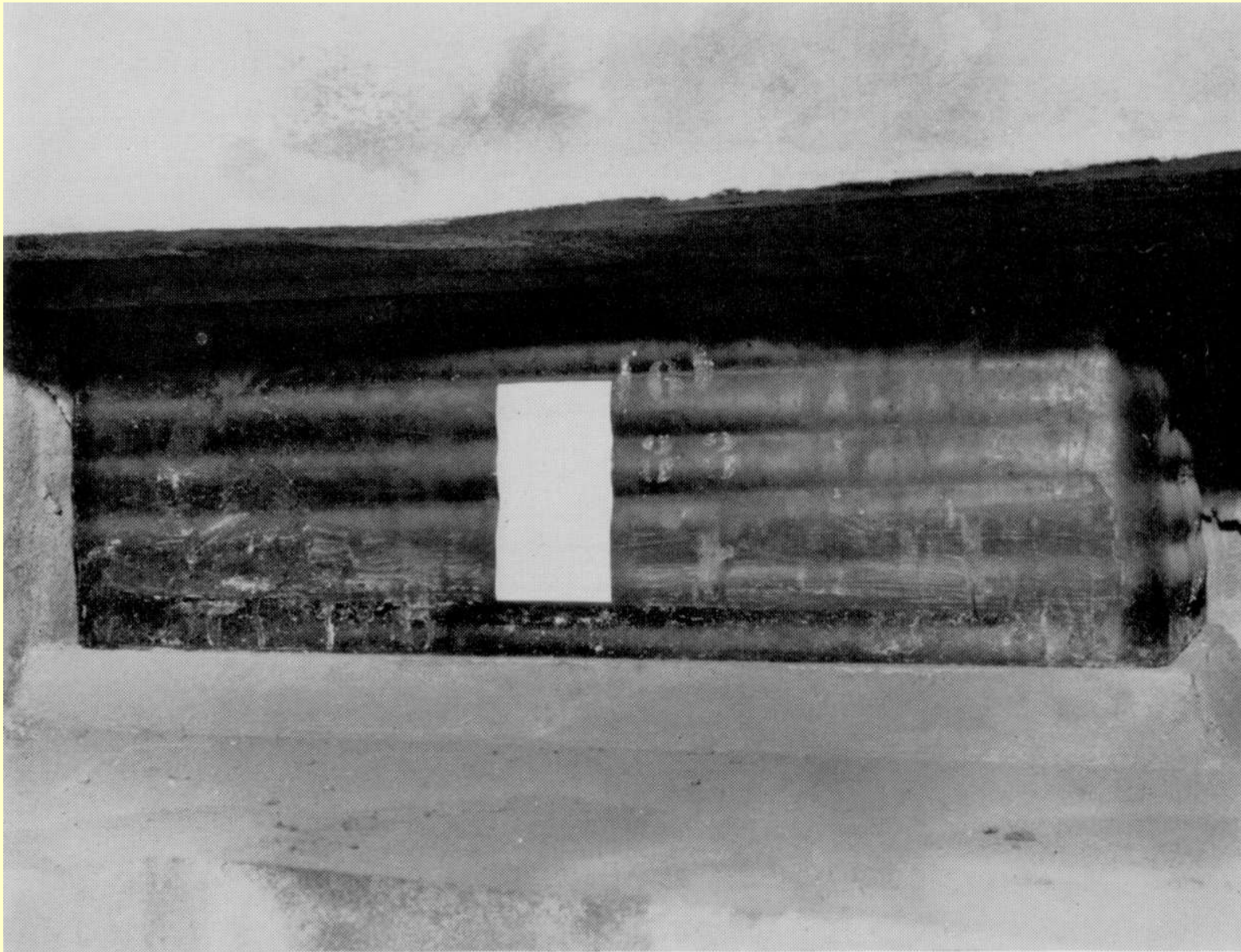


FIG. 10.2. One of the springs used in Albany Court.

**Albany Court - London - 1964**





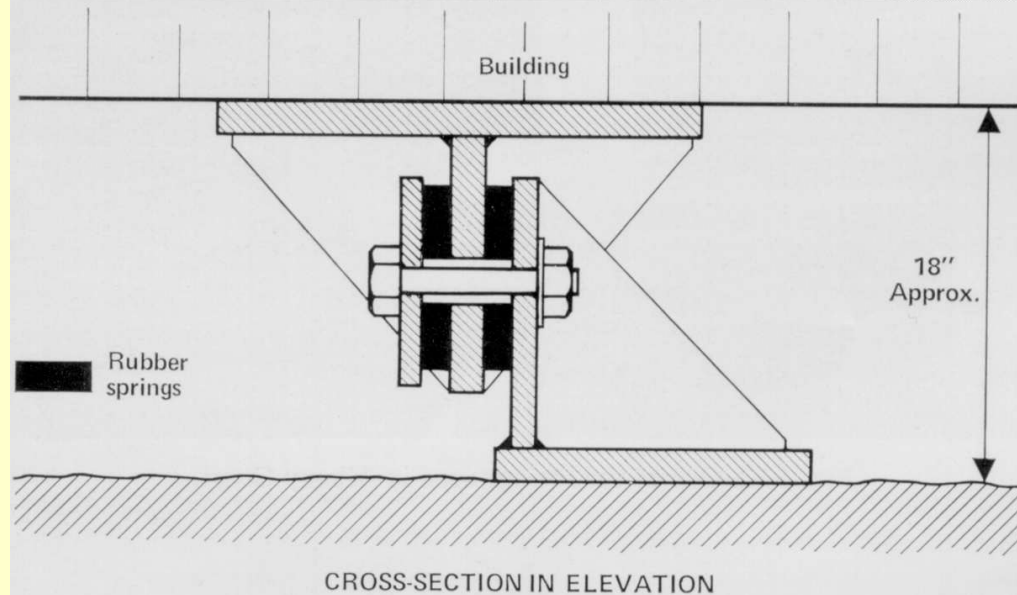
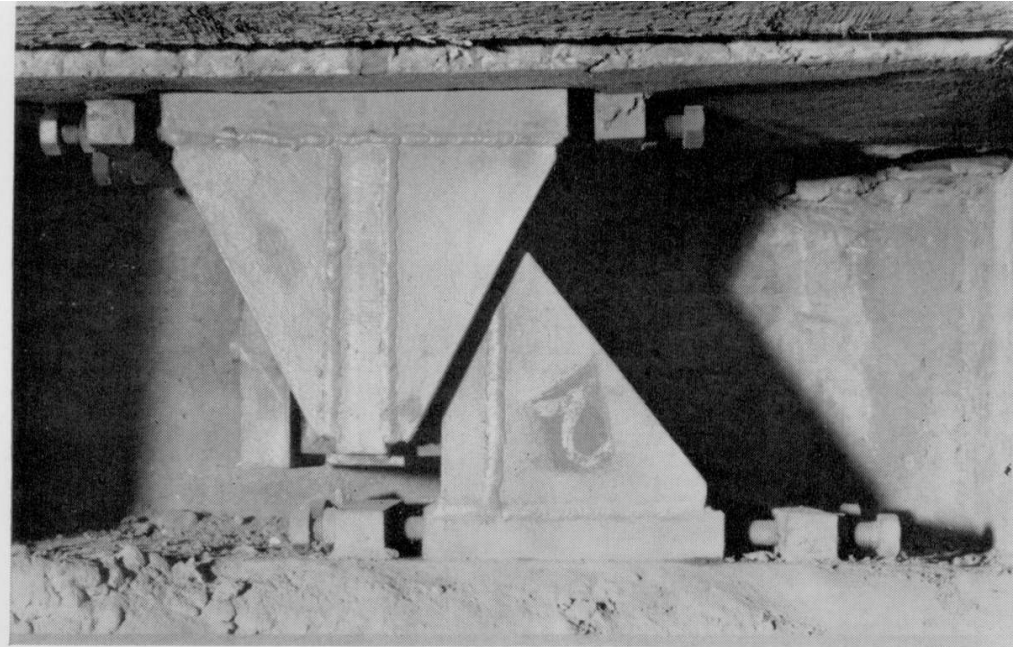
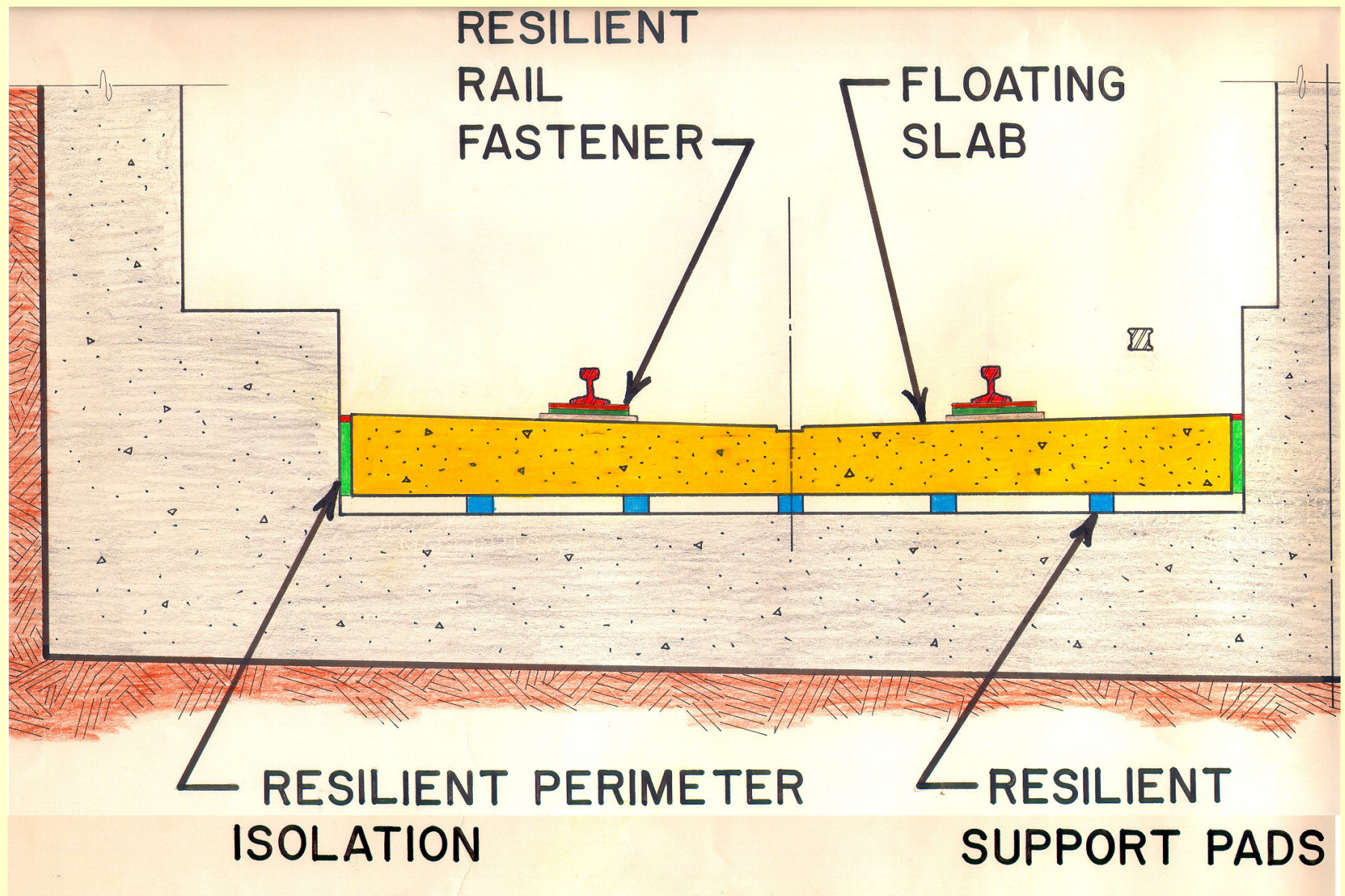


FIG. 10.3. Horizontal restraining spring, Albany Court.

## Albany Court - London - 1964







**WMATA METRO Floating Track Slab - 1972**











**TTC Double Tie Adjustable Side Pad**

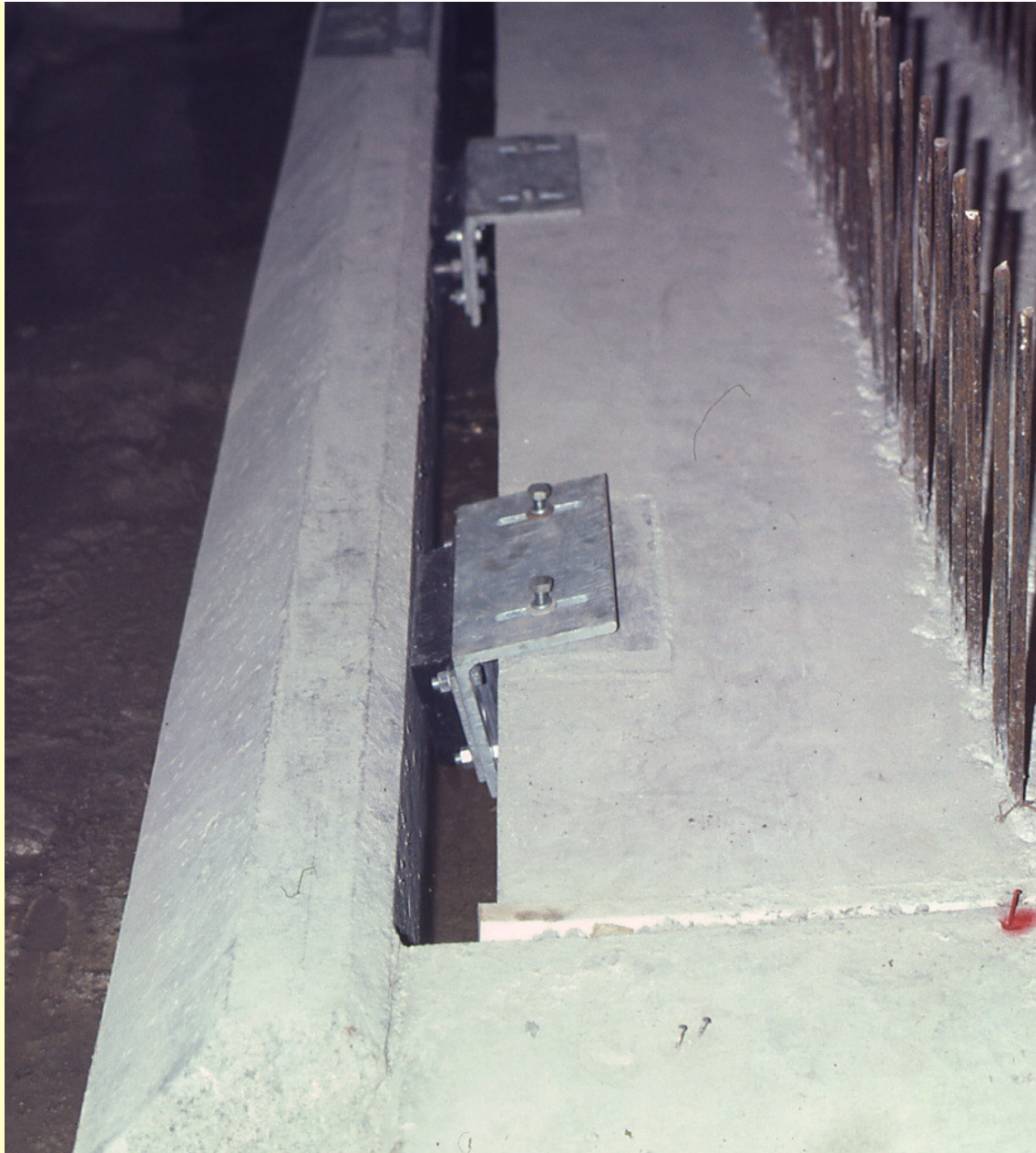




**TTC Double Tie Adjustable Side Pad**







**Hong Kong Continuous FST Adjustable Side Pad**







**Birmingham UK Concert Hall - 1980**







**Burnham Plaza Theater - Chicago - 1986**







**Burnham Plaza Theater - Chicago - 1986**







**Burnham Plaza Theater - Foundation Status  
When Isolation Design Requested**







**Burnham Plaza Theater - Column Isolation at  
Garage Floor Level**







**Burnham Plaza Theater - Perimeter Wall  
Isolation  
at Garage Floor Level**







**Burnham Plaza Theater - Isolation at  
Adjacent Building**



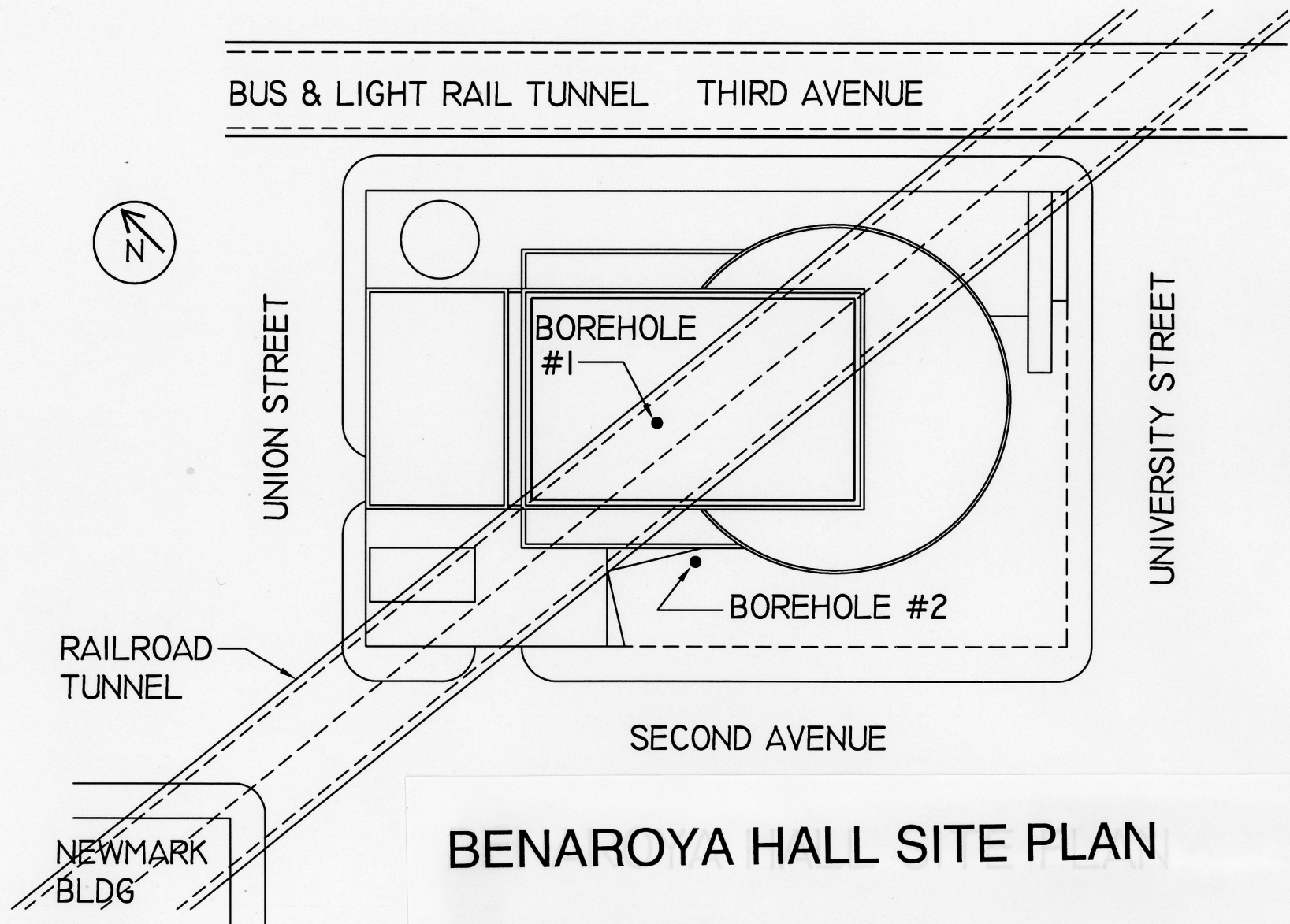




**Seattle – Benaroya Concert Hall - 1997**







**Benaroya – Site Plan**



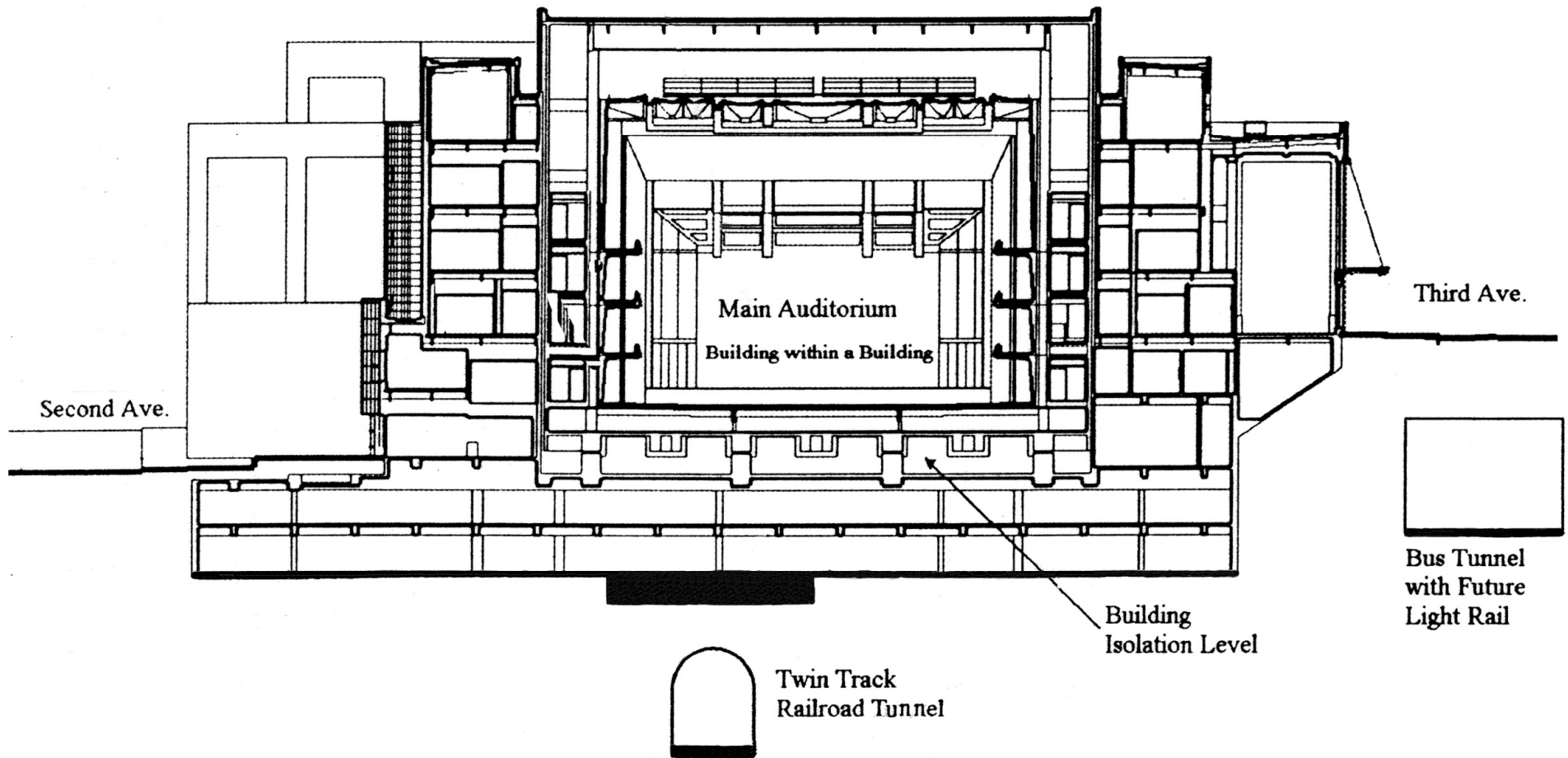




**3rd Avenue Bus Tunnel Station**







**Benaroya Hall – Section Showing Tunnels and Isolation Elements**



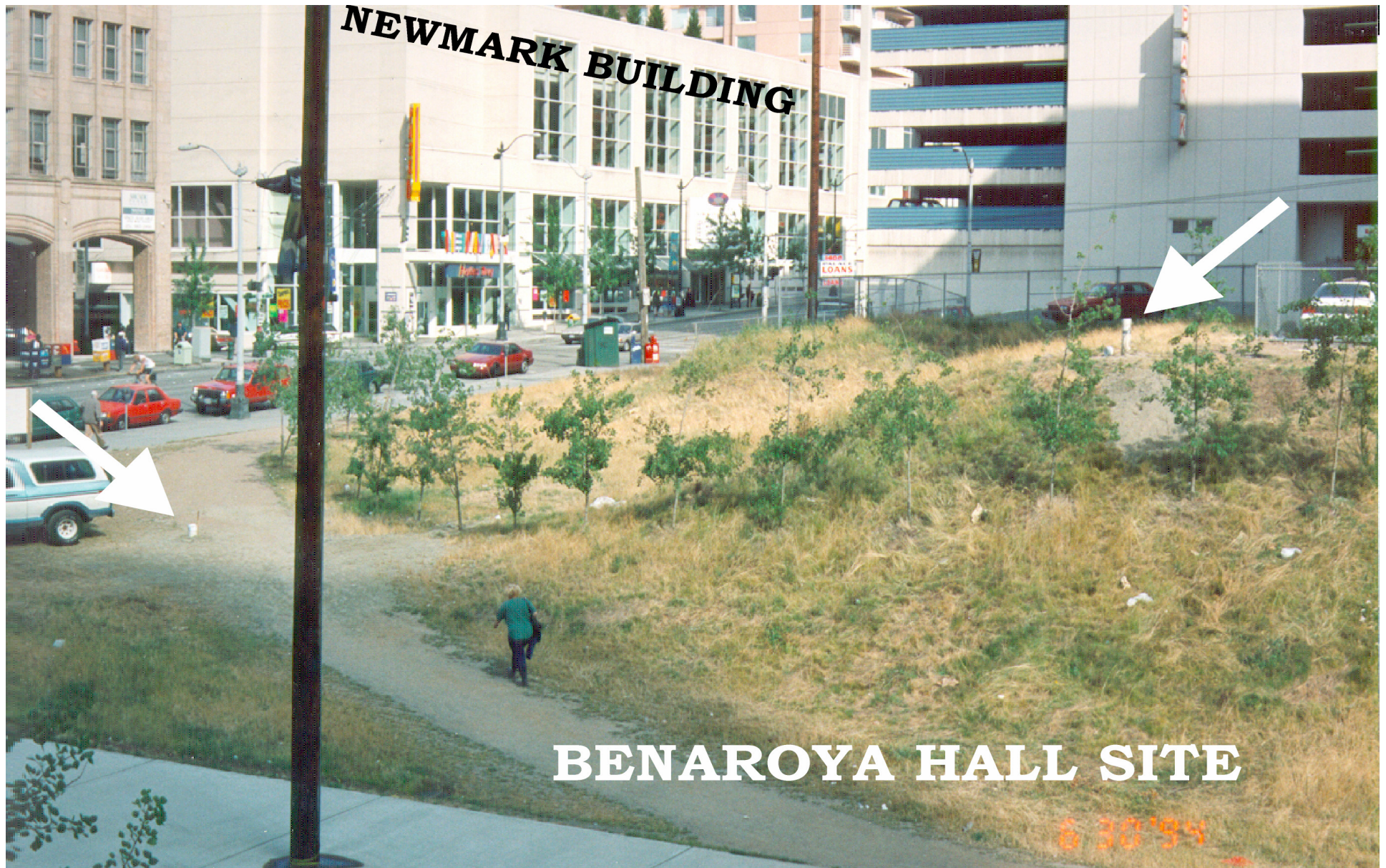




**Groundborne Vibration Measurement Tools**







## Groundborne Vibration Measurements at Site







**Entrance to 3rd Avenue Tunnel Station**



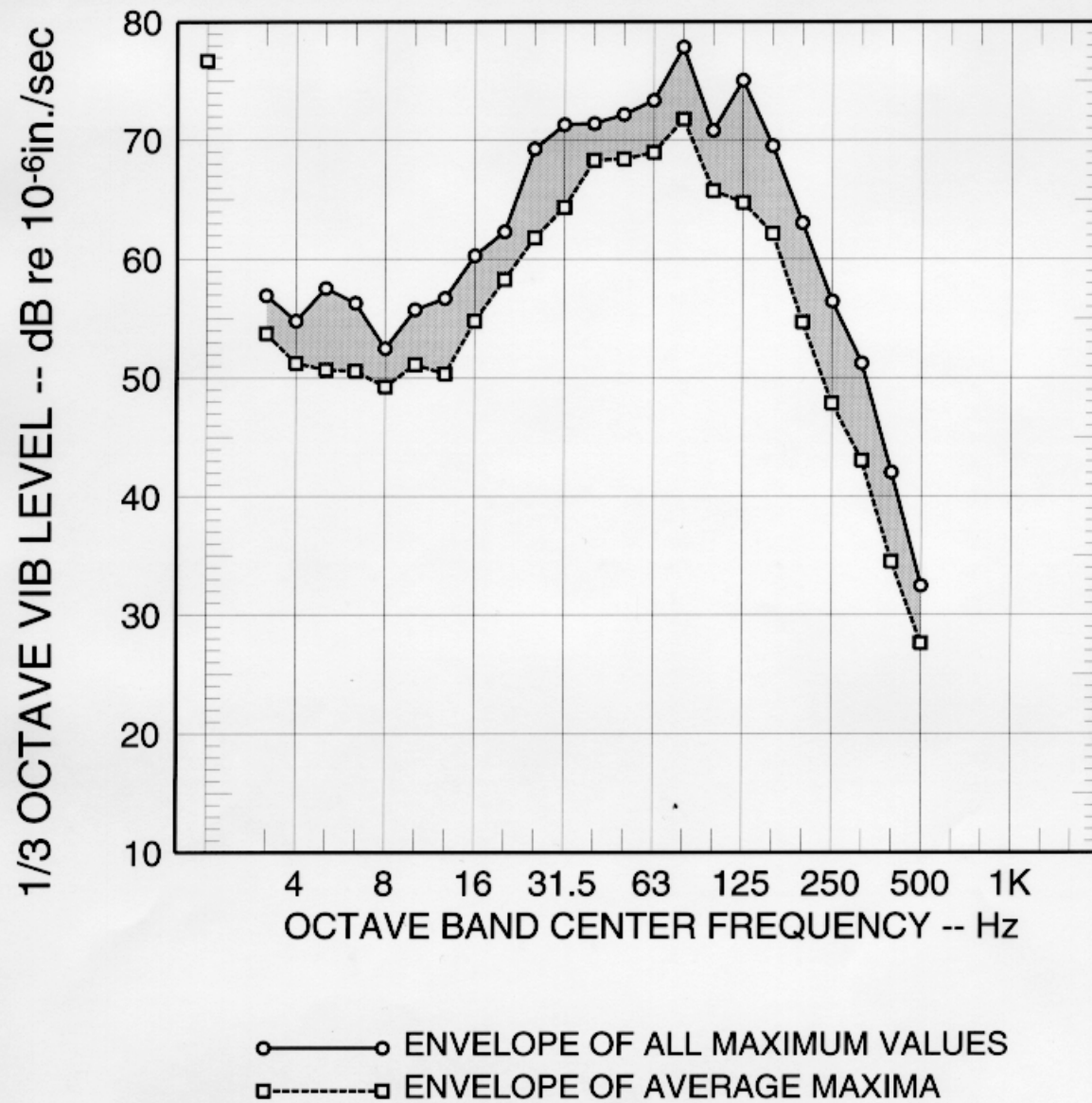




**Measurement Site Near Tunnel Station  
Entrance**



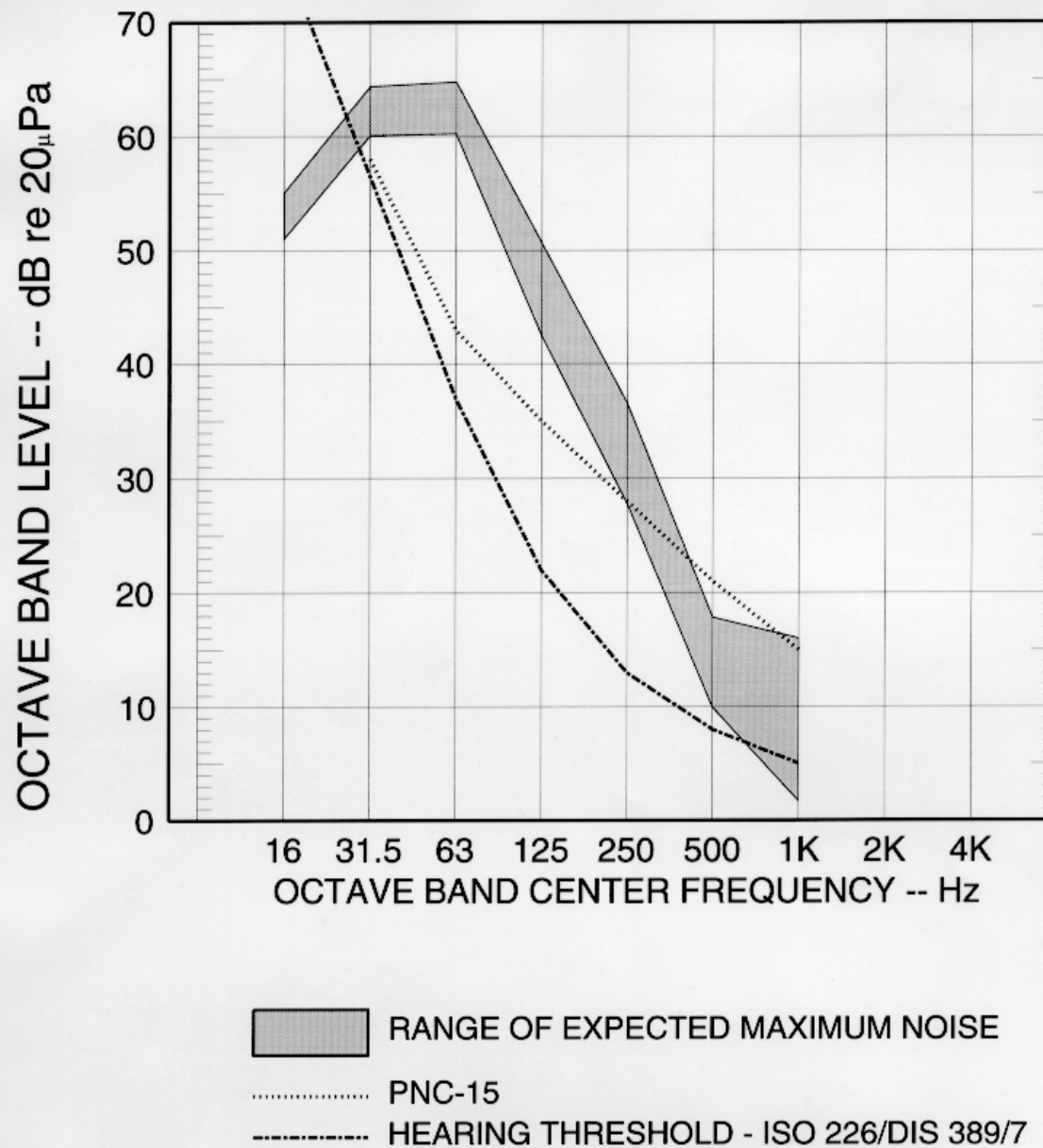




**Data from Borehole Measurements of  
Groundborne Noise from Trains in Tunnel**



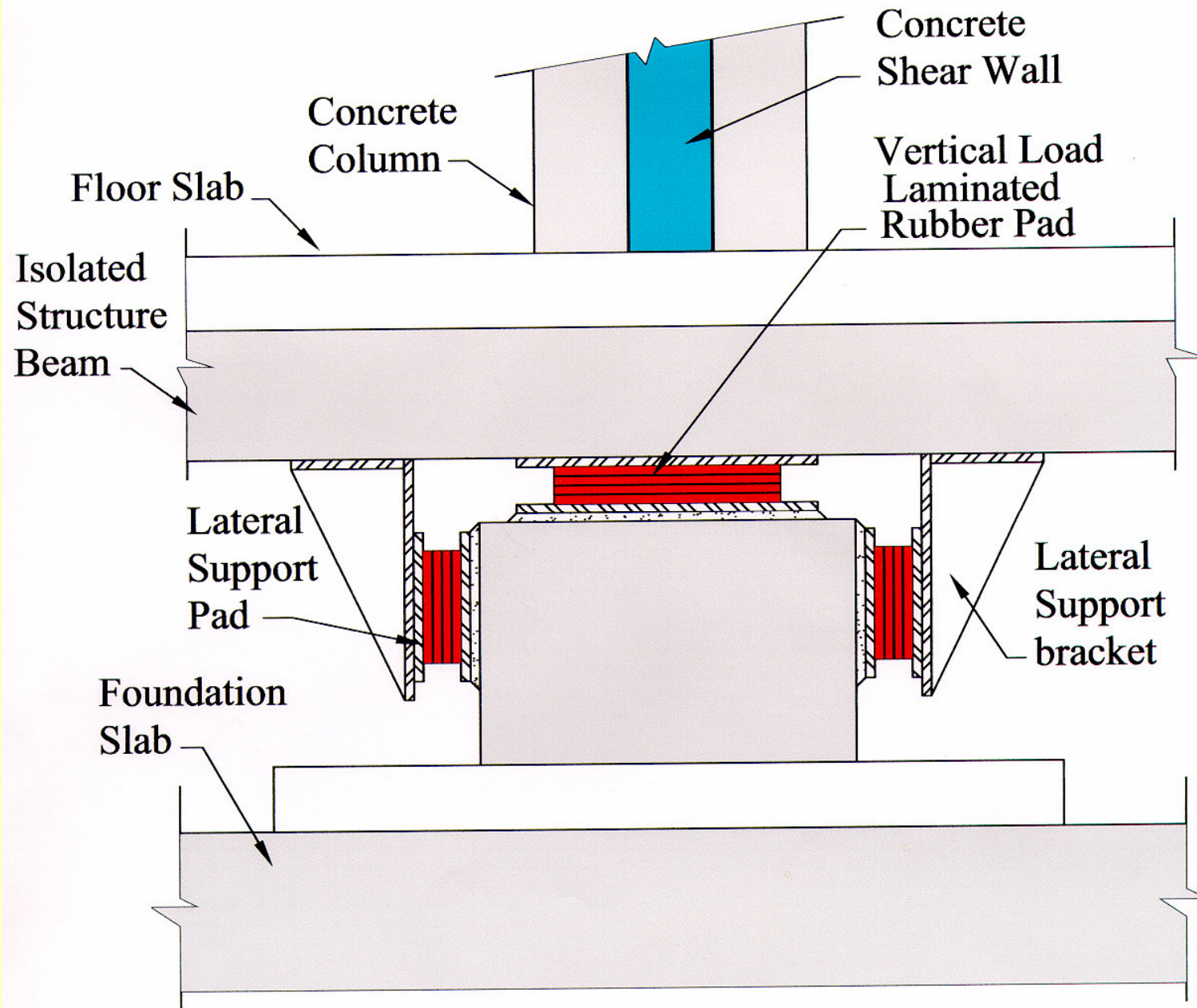




## Expected Radiated Noise in Benaroya Hall Without Vibration Isolation



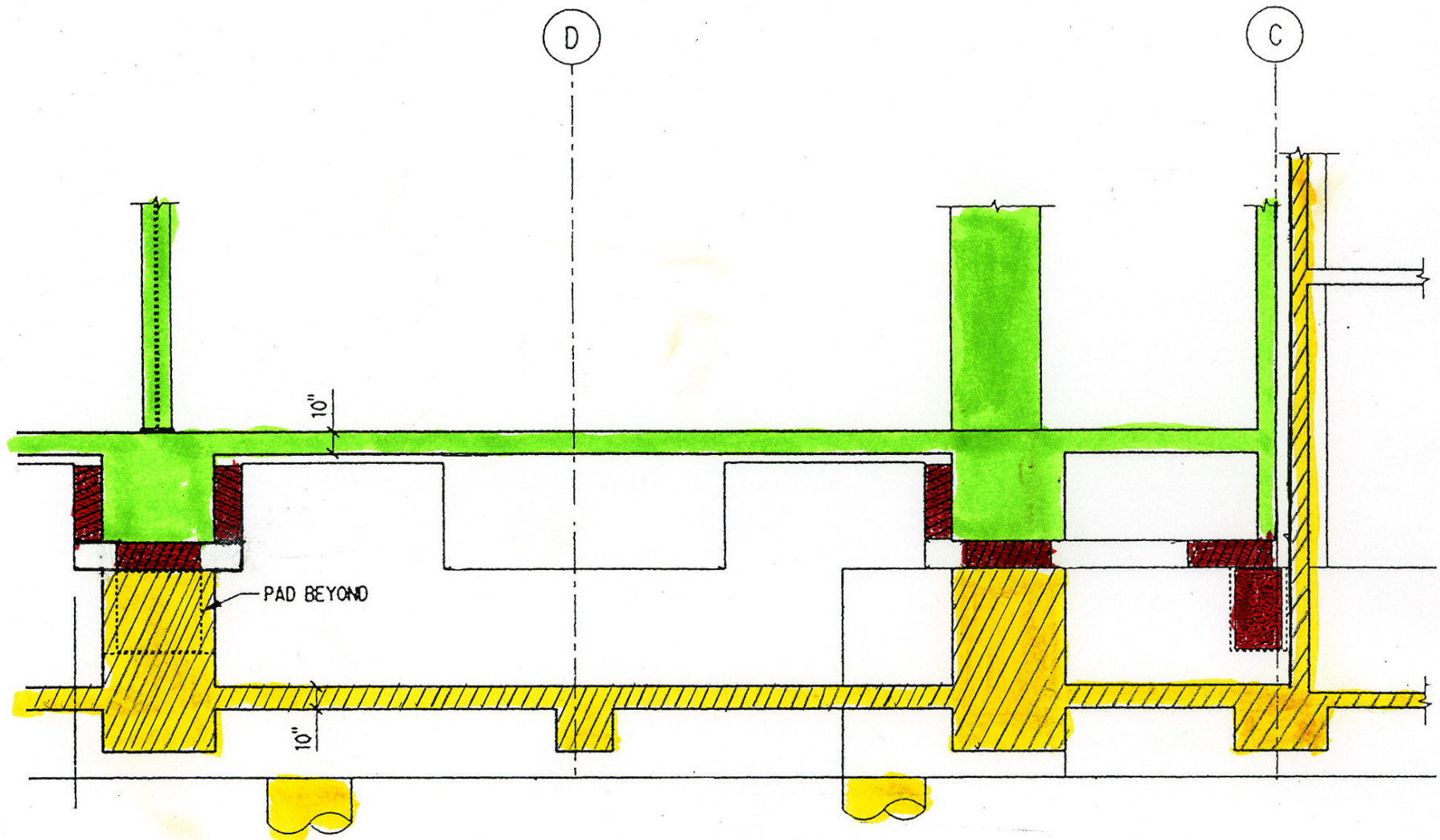




## Essential Elements for Building vibration Isolation







**Isolation Design for Benaroya Hall**







**Vertical Support Pads - 15"x15"x7"**







**Lateral Restraint Pad - 21"x21"x7"**







**Benaroya Hall Initial Construction**







**Support Beam and Pad Installation**







**Side Pad and Vertical Pad Installation**







**Benaroya – Form with lower grout pad in place**



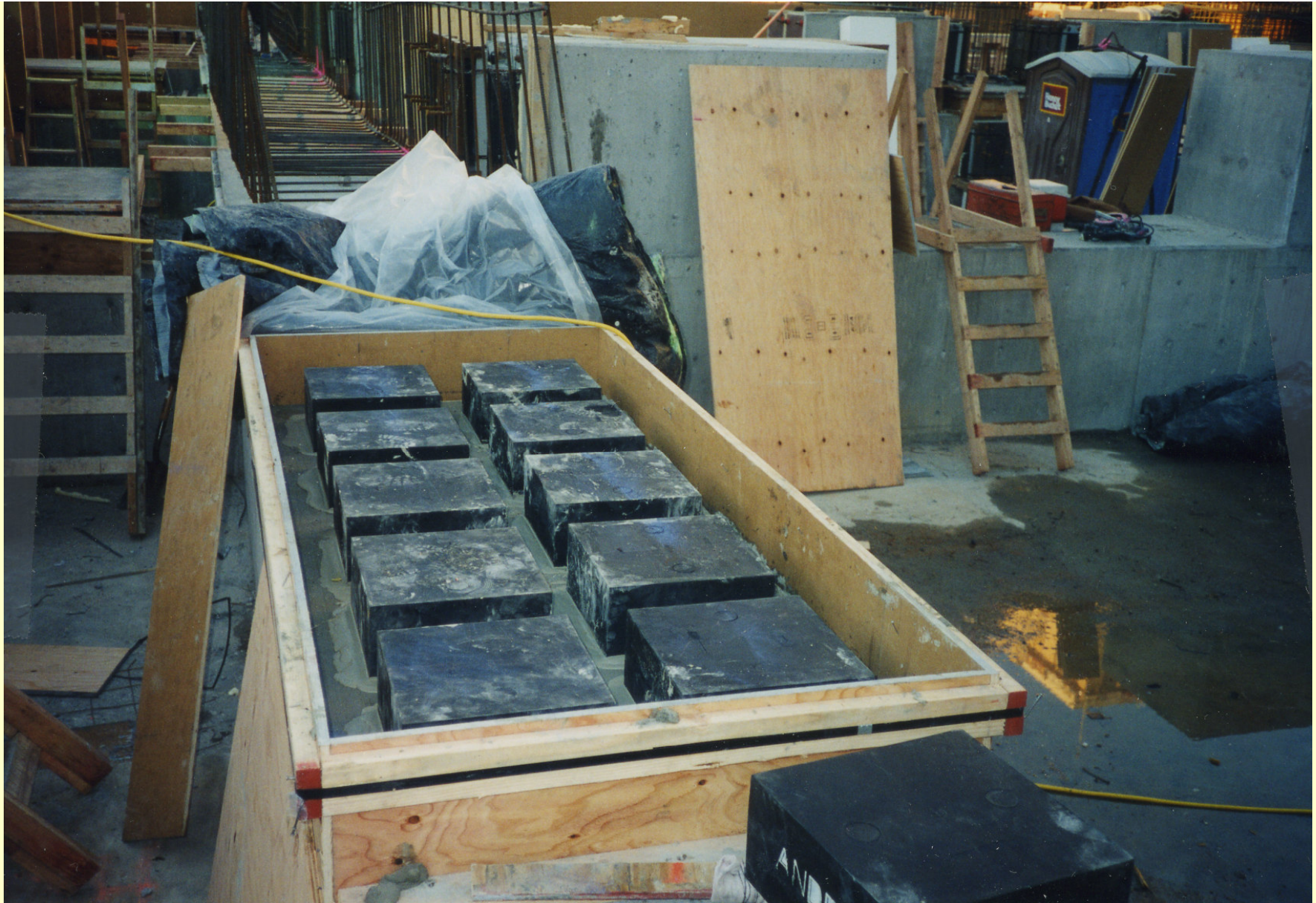




**Benaroya – Pads in form, before sand placement**







**Benaroya – Pads in form, before sand placement**







**Benaroya – Completed vertical pad assembly**



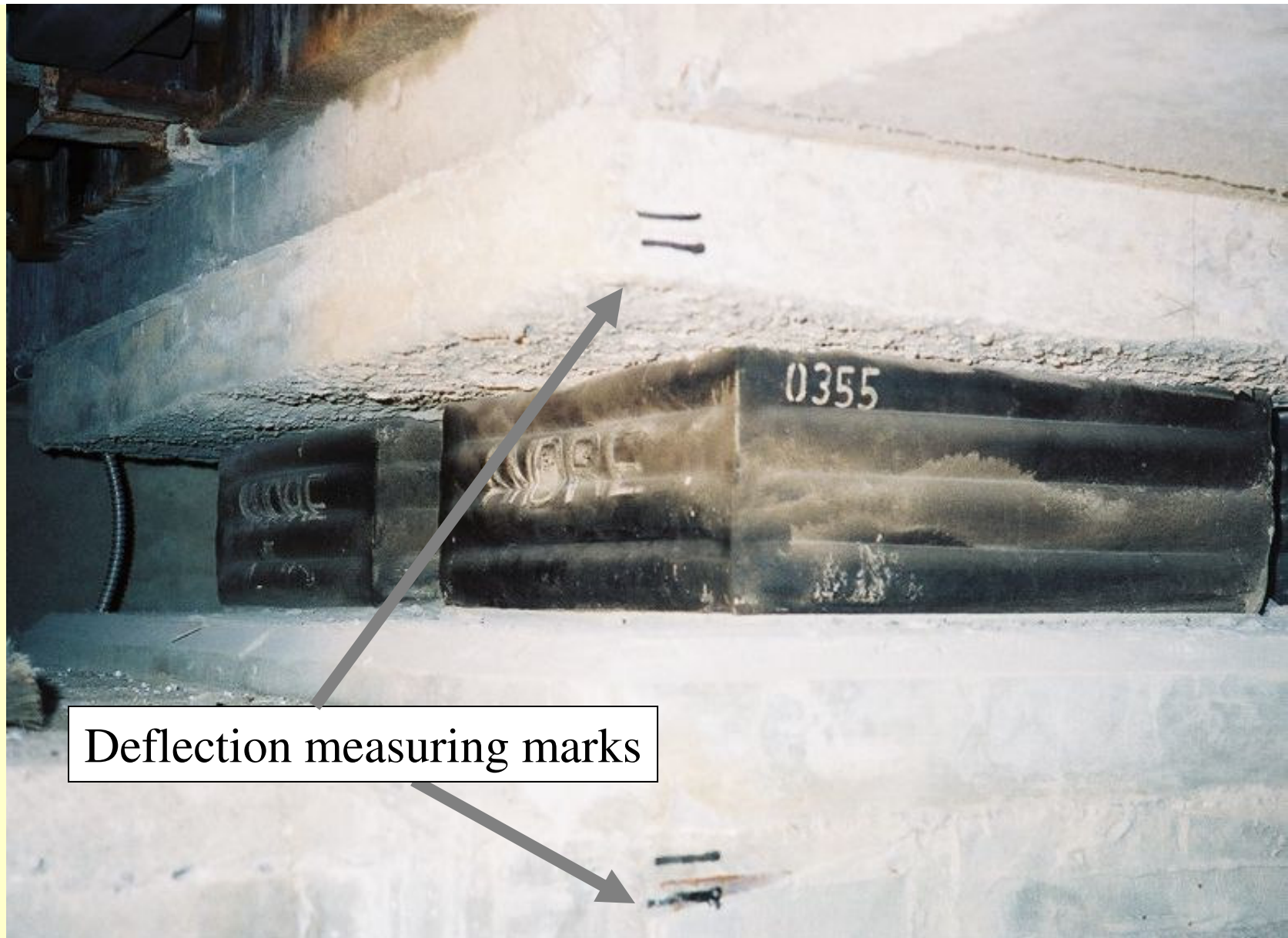




**Vertical Pad Assembly Before Loading**







**Benaroya – Fully loaded vertical pad assembly**







**Benaroya – Vertical and Lateral Pad Assemblies**





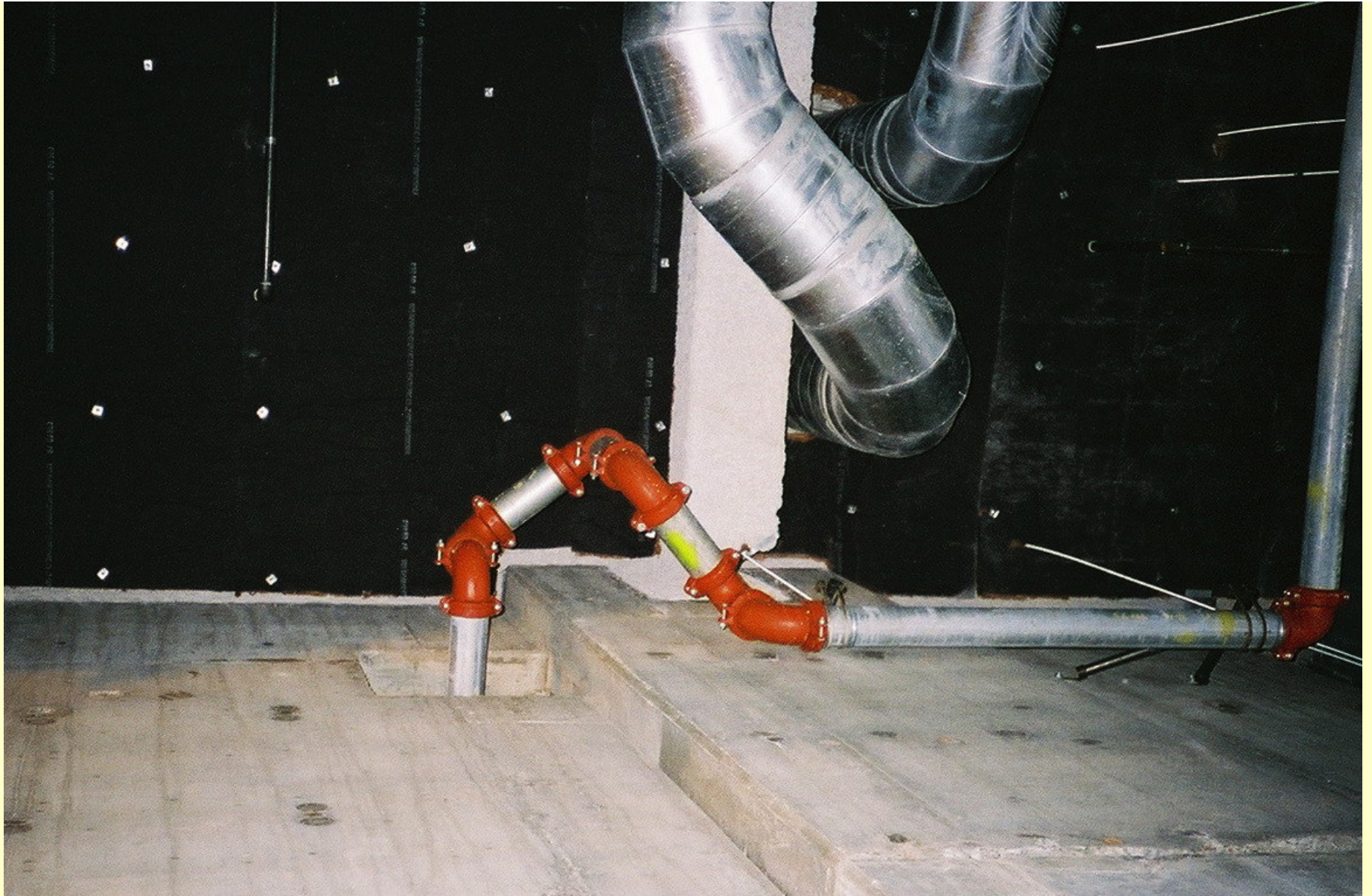


Liquid-tight flex conduit

## Benaroya – Electrical Conduit Isolation





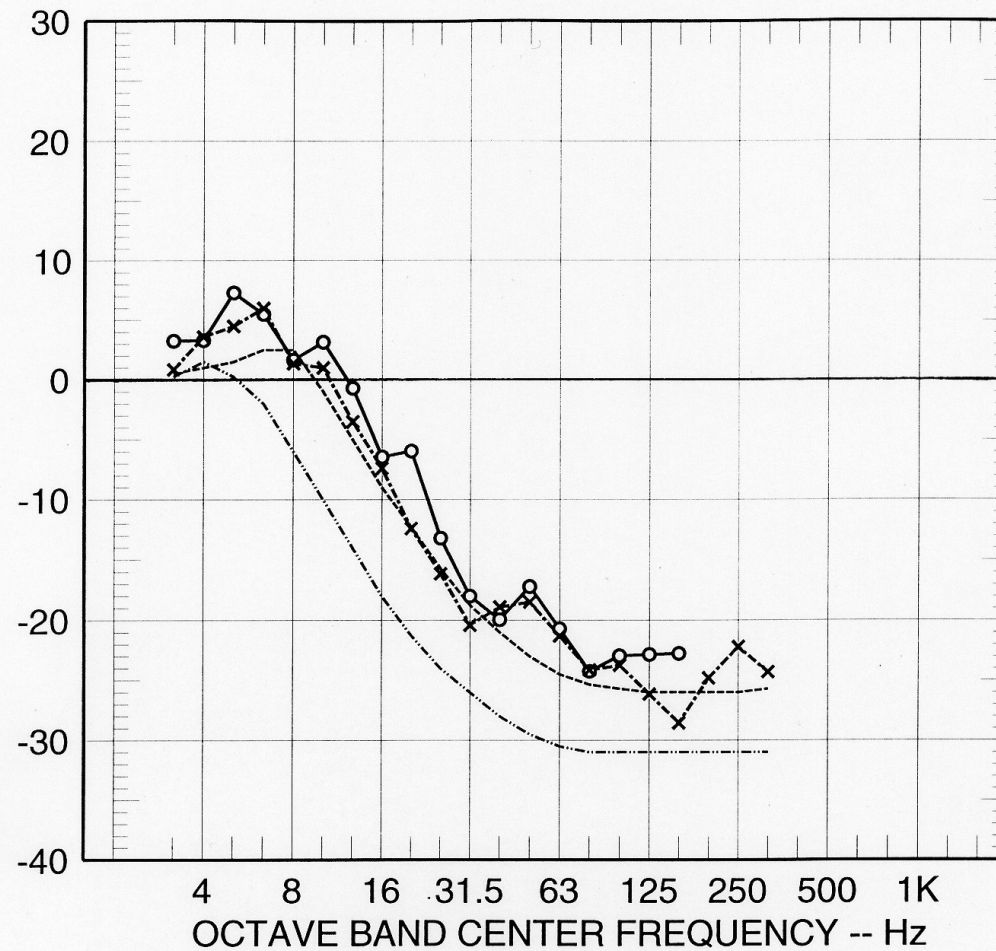


**Benaroya – Fire Sprinkler Line Isolation**





RELATIVE VIBRATION LEVEL -- dB



○—○ FREIGHT TRAINS

x- - - x PASSENGER TRAINS

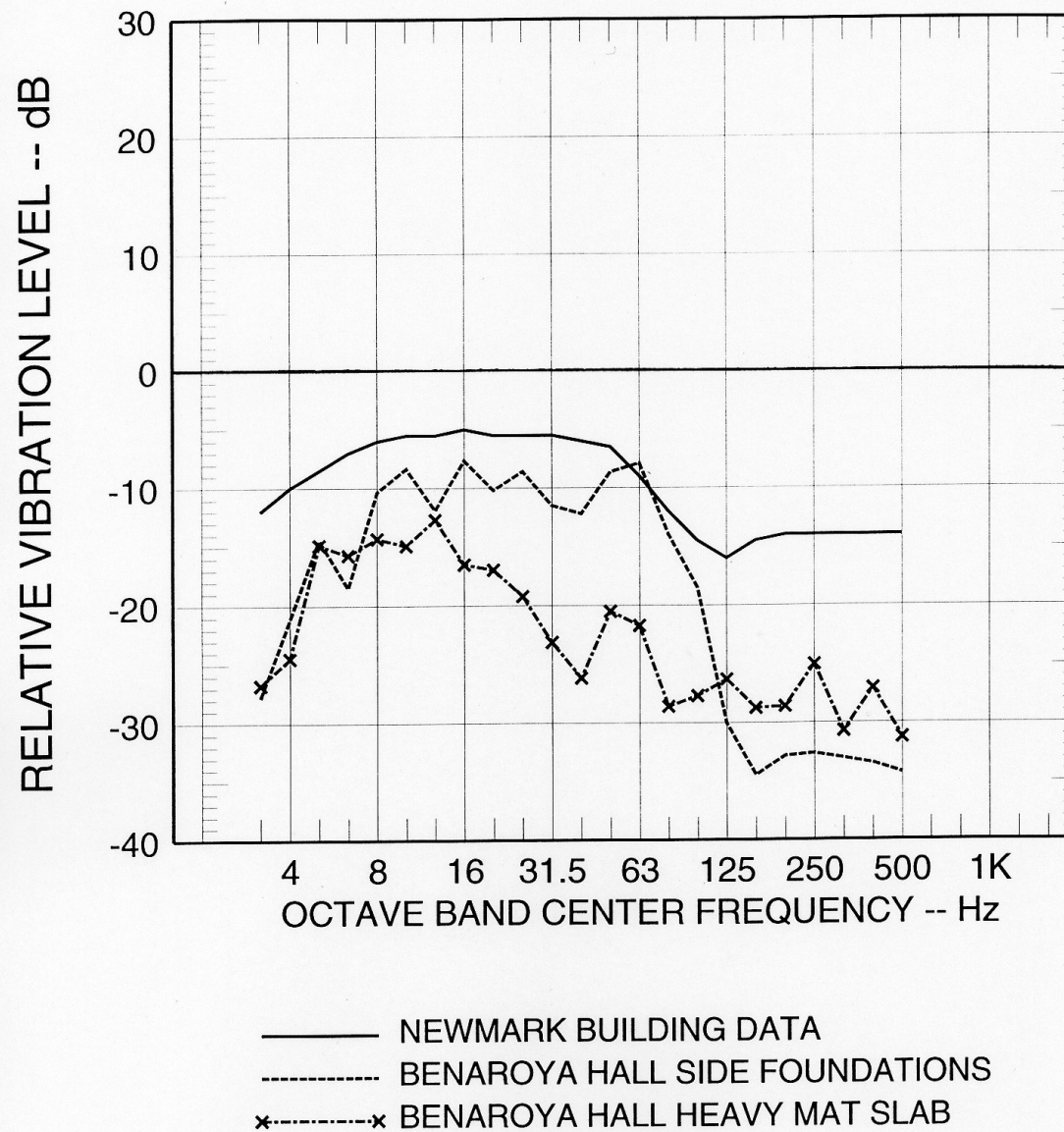
- - - - - 6-8Hz ISOLATION LOSS PROJECTED

- . - . - 4Hz ISOLATION LOSS PROJECTED

VIBRATION REDUCTION ACROSS  
RUBBER ISOLATION BEARINGS





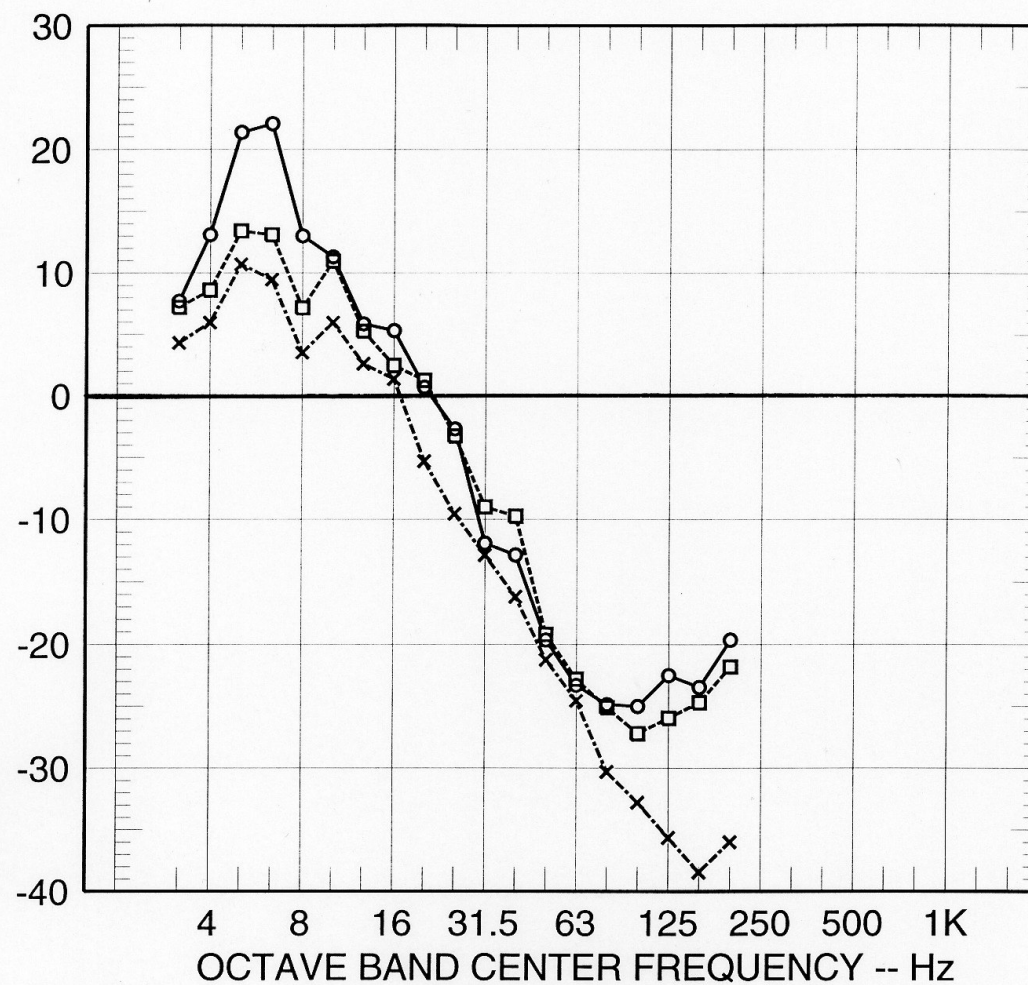


COUPLING LOSS AT LOWEST BASEMENT  
OR FOUNDATION LEVEL





RELATIVE VIBRATION LEVEL -- dB



- MAIN FLOOR SEATING AREA
- STAGE FLOOR
- \*-----\* STRUCTURE JUST ABOVE ISOL PADS

OVERALL REDUCTION FROM  
BASEMENT TO AUDITORIUM







**1998 Tour Group Above Isolation Level**







**Through the Manhole to the Isolation  
Level**







**Benaroya Hall**

